Health, Height and the Household at the Turn of the 20th Century

By

Roy E. Bailey (University of Essex)

Timothy J. Hatton (University of Essex and Australian National University)

and

Kris Inwood (University of Guelph)

July 2014

ABSTRACT

We examine the health and height of men born in England and Wales in the 1890s who enlisted in the army at the time of the First World War, using a sample of recruits from the army service records. These are linked to their childhood circumstances as observed in the 1901 census. Econometric results indicate that height on enlistment was positively related to socioeconomic class, and negatively to the number of children in the household in 1901 and the proportion of household members who were earners, as well as to the degree of crowding. Adding the characteristics of the locality makes little difference to the household-level effects. But local conditions were important; in particular the industrial character of the district, local housing conditions and the female illiteracy rate. We interpret these as representing the negative effect on height of the local disease environment. The results suggest that changing conditions at both household and locality levels contributed to the increase in height and health in the following decades.

Keywords: Heights of recruits, Household structure, Health in Britain.

JEL Codes: I12, J13, N33

Acknowledgements: We thank the ANU College of Economics and Business for a Research School Grant and the Social Sciences and Humanities Research Council of Canada for financial support under Grant No. 41020092342. We are grateful to Danielle van Wagner, Jeremy van Dyke and Mitsumasa Aoki for excellent research assistance. For useful comments we thank three anonymous referees as well as participants at seminars at Essex, Hamburg, the London School of Economics, the Economic History Society conference at Warwick and the Cliometrics conference at Clemson.

Introduction

An extensive literature has examined the heights of children and adults during the nineteenth century, and earlier, to provide a window on the proximate determinants of health. Height is influenced both by nutrition and by the disease environment during infancy and childhood. Most studies of the heights of adults analyze military recruits or conscripts but the information on childhood circumstances is often limited to characteristics of the locality in which they were born and sometimes to the occupation of the individual or that of his father. Yet the inferences drawn from these studies often relate to conditions within the household, for which local area characteristics can only be a rough proxy. As a result it has not generally been possible to distinguish between those effects that genuinely stem from within the household and those that arise from the locality, such as the local disease environment. This distinction may be important for understanding the socioeconomic determinants of health and height and it may contribute to explaining both cross-sectional variations and long-run trends.

In this paper we analyze a sample of soldiers who enlisted in the British army around the time of the First World War. Given the vast numbers that were recruited, this is likely to be a more representative cross-section of British males than samples observed in peacetime. And all the more so as the focus is exclusively on those born in the 1890s, who were young adults during the War and for whom enlistment rates were extremely high. In order to capture the conditions in which they grew up, we seek to identify the household of each serviceman in the 1901 census. Because the census is searched for each serviceman separately using the information recorded upon enlistment, a remarkably high match rate of approximately 85 per cent is achieved. Also each serviceman and his childhood household is linked to the characteristics of the local registration district in which the household lived, thus enabling a much finer classification of local conditions that would be possible at the county level.

Our findings point to a number of household characteristics that affect height through both nutrition and disease, and thus are associated with differences in adult stature. The first is the negative association between height and the number of siblings, a result consistent with the hypothesis of a trade-off between the ‘quantity’ (number) of children and their ‘quality’ (in terms of health). Other results include a negative effect of overcrowding on height as well as a negative effect of the share of earners in the household (ratio of earners to total household membership). Not surprisingly the serviceman’s stature is associated also with the occupational class of the head of household. However, local conditions still matter, in particular the disease environment as represented by infant mortality. Underlying this is the degree of overcrowding in the locality, its industrial character and the extent of female illiteracy. The last of these supports the idea that a more educated female population was conducive to the better nurturing of children.

Childhood determinants of height

A large literature has explored the socioeconomic circumstances that influence the average heights of populations in the eighteenth and nineteenth centuries and how these factors have evolved over time.[1] Important influences on height have been identified in a wide variety of cross-sectional studies as well as in those that examine changes over time. Cross-sectional studies of individual heights potentially offer more nuanced insights than can be obtained from variations in average height across regions or over time. But studies of individual heights, such as army recruits or convicts, often suffer severe limitations because they lack detailed information on socioeconomic conditions during childhood.[2] Thus inferences have to be based on little more than place of birth characteristics and occupation or father's occupation. As a result there is little direct evidence on the childhood household-level correlates of height.

One issue in the literature is the distinction between the influence of household circumstances and the effect of conditions in the locality, a distinction that is sometimes referred to as 'composition versus context'. When only the locality variables are available it is unclear if these represent genuine locality effects or if they simply reflect an average of household effects. Thus "neighbourhood level variables may act partially or entirely as proxies for individual attributes and a partition of the contribution of each to the chosen health outcome is impossible. Without neighbourhood level measures, the impact of individual characteristics may be misunderstood."[3] The weight of evidence in studies of modern data is that the locality plays only a minor role, but the effects could be quite different for the nineteenth century.[4] Distinct locality effects would include not only the built environment, the sanitary infrastructure and industrial pollution but potentially also human and social capital.[5]

At the household level a number of conditions are important for child health and growth. Perhaps most important is the socio-economic status of the household. This is typically represented by the occupational class of the head of household—often the fathers of the individuals whose heights are analysed. Not surprisingly, differences in height by social class,

[1] Comprehensive surveys are provided by Steckel, 'Stature and the standard of living' and 'Heights and human welfare'.

[2] Notable studies among a long list include Humphries and Leunig, 'Cities, market integration', Horrell and Oxley, 'Bringing home the bacon', A'Hearn, 'Anthropometric evidence', Baten and Murray, 'Heights of men and women' and Baten, 'Protein Supply and Nutritional Status'. A few studies such as Lantzsche and Schuster, 'Socioeconomic status' include a wider array socioeconomic variables, but these are observed at the time of enlistment rather than during childhood. Haines et al., 'The short and the dead', match records for Union Army soldiers with household data, but only for wealth and head's occupation.

[3] Pickett and Pearl, 'Multilevel analyses' p. 116.

[4] Pickett and Pearl, 'Multilevel analyses' p 111; Stafford and Marmot, Neighbourhood deprivation,' p. 357; Martikainen et al., 'Effects of the characteristics of neighbourhoods', p. 213; Komlos and Lauderdale, 'Spatial correlates of US heights', p. 71.

[5] Newell and Gazeley, 'The declines in infant mortality' provide evidence that sanitary reforms reduced infant mortality in English towns at the turn of the century. For a recent survey of empirical work on social capital and health-related outcomes for children, see Vynke et al., 'Does neighbourhood social capital aid'.

and changes in those differentials, have been widely analysed.[6] But their interpretation is less than transparent, not least because of clustering by locality. Taken alone, occupational class stands for a variety of factors, the most obvious of which is income, but it may also capture the separate effects of education, skills, standards and behavioural norms that independently affect the health of children. On the other hand, even if social or occupational class were a good proxy for income, its effects may work through housing quality and overcrowding as well as diet and nutrition. In Victorian households the head's income could be supplemented by that of other earners and so the number and composition of earners might also be important. But even this might have mixed effects, depending on how time and resources were distributed among different family members by age, sex and labour market status. [7]

Household demographic structure is likely to matter, particularly the number of children in the family. As Rowntree found in his 1899 survey of York, large families were a common 'cause' of poverty.[8] Biographical testimony evidence also provides graphic evidence that large families were often associated with disadvantage and privation among children.[9] Although the idea of a trade-off between the number of children in a family and their average health is familiar, quantitative evidence for the nineteenth century is thin. Some studies have identified a negative relationship between fertility and height in aggregate time series, but there is little evidence at the household level.[10] One exception is evidence from the Boyd Orr cohort of children in poor families in the 1930s, which strongly supports the view that larger families were associated with shorter stature.[11]

An issue that concerned contemporary observers was whether or not mothers' working in the labour market was deleterious to the health and survival of their children. On one hand working mothers may have less time for nurturing children, but on the other hand they may have fewer children and more income. Such hypotheses can be examined only with data at the household level. The demographic structure of the household may influence child health not only through the availability of nutrition but also via the transmission of disease. The latter is often linked with overcrowding, or more precisely with the interaction between housing quality and household size. This was a perennial concern of late nineteenth century medical professionals, who drew strong links between overcrowding and the spread of infections, especially as a cause of infant and child mortality.[12] A number of studies have found strong

[6] Lantzsch and Schuster, 'Socioeconomic status and physical stature' include occupation of both conscripts and their fathers. Among the many studies that examine the effects of socioeconomic status are Cavelaars et al. 'Persistent variations' and Breschi et al., 'Social status'.
[7] Horrell and Oxley, 'Crust or crumb?'
[8] Rowntree, P*overty,* pp. 120-1, 134-7.
[9] Humphries, 'Because there are to menny'.
[10] See Weir, 'Parental consumption decisions'; Schneider, 'A historical note on height'.
[11] Hatton and Martin, 'The effects on stature'.
[12] Notable among these was Sir Arthur Newsholme who was Medical Officer of the Local Government Board from 1909 to 1919 and Sir George Newman Chief Medical Officer to the Board of Education from 1907, and then from 1919 Chief Medical Officer to the newly created Ministry of Health. See the admirable summary of their respective views in Woods, *The demography of Victorian England and Wales*, pp. 280-295.

associations between health outcomes and overcrowding, but almost always at the aggregate level.[13] As a result it is unclear how far housing conditions affect the individual household directly and how far they stand as a proxy for conditions in the locality.

Turning to the local environment, attention has frequently been drawn to the differences in height, and even greater differences in mortality, between rural and urban locations in the late nineteenth century.[14] The height advantage of those from rural locations is typically associated with better access to fresh food (or at least to lower prices) and to lower exposure to infections that were endemic to towns and cities. Such differences are often seen as locality effects but taken alone they would also capture compositional effects such as differences in income, housing and family structure. Some studies also find that proximity to sources of basic foods such as grain, vegetables, milk and butter, and meat products had significant associations with height.[15]

Perhaps even more important is the link between population density and height. A number of studies have found that larger and more industrial cities were linked with shorter stature. High density is associated with poor housing quality and overcrowding and this may simply reflect the circumstances of individual households. But the widespread presumption is that high population density captures the local disease environment. Indeed, nineteenth century cities are famous for grime, squalor and lack of sanitation, not to mention industrial pollution. Consistent with this, one recent study points to effects stemming from the surrounding area and not just from the immediate vicinity.[16] But the gradual, if uneven, advance of sanitary reforms, improved public amenities, cleaner streets and suburbanisation helped to remove some of the disease vectors. As a result the effects captured by population density may have become weaker and more heterogeneous towards the end of the nineteenth century.

One way to capture the influence of the local health environment is via average health outcomes. The most widely used measure is the infant (or sometimes child) mortality rate. This could have two opposing effects. On one hand higher infant mortality might leave healthier and taller survivors—the selection effect. On the other hand, as a proxy for the risk of infection, it may result in shorter stature—the scarring effect. Existing evidence points to a strong negative relationship between height and the rate of infant mortality around the time of an individual's early childhood, suggesting that the scarring effect dominates.[17] In the nineteenth century spatial and temporal variations in infant mortality were associated largely with respiratory infections, notably pneumonia and bronchitis, and gastro-intestinal

---

[13] See for example, Burstrom et al, 'Child mortality in Sweden'; Cage and Foster, 'Overcrowding and infant mortality'.

[14] On the interpretation of urban-rural mortality gaps, see Williams and Galley, Urban-rural differentials'; Szreter and Mooney, 'Urbanisation, mortality and the standard of living'; Woods, *The demography of Victorian England and Wales,* Ch. 9.

[15] See Baten and Murray, 'Heights of Men and Women'; Baten, 'Protein Supply and Nutritional Status'.

[16] Humphries and Leunig, 'Cities, market integration'; see also Komlos and Lauderdale, 'Spatial correlates of US heights'.

[17] Hatton, 'Infant mortality', Bozzoli et al. 'Adult height and childhood disease'.

infections, especially diarrhoea and dysentery. These types of infection, especially when recurrent, were precisely those that slowed growth during childhood. It is important to note, however, that while infant mortality stands as a proxy for some elements of the disease environment, it represents an outcome of a variety of deeper causes, some of which are noted above.

To summarise, the existing literature points to a variety of economic and demographic circumstances that affect both nutrition and infection, and that promote or restrict growth during childhood. But many of the inferences, particularly for the nineteenth century and earlier, are indirect in the sense that they are derived from the relationship between individual heights and the characteristics of regions or localities. The most important limitation has been the lack of information on household circumstances during childhood. A related issue is the degree to which locality effects influence health during childhood once household circumstances are taken into account.

Data

We construct a database of the heights of men who served in the British army around the time of the First World War. These come from the army service records, which have now been made available online largely for the benefit of genealogists.[18] Our focus is on the records that are located in the file WO363, also known as the 'burnt documents'. As a result of fire at the War Office building at Arnside Street, London in September 1940, approximately three fifths of the records were destroyed by fire and many others were damaged. The surviving documents contain records of around two million servicemen who completed their army service between 1914 and the early 1920s. They exclude recruits to the navy and those who entered the army as officers, for whom there exist no comparable records. Much of the information that we use here comes from the attestation form completed upon enlistment. While several different types of attestation form were used, almost all include the date and place of attestation, the name, age, sometimes the birthplace, and usually the address of the serviceman and his next of kin. Normally a medical inspection report is also present, recording various physical characteristics, most importantly height.

The records were sampled using the genealogical website Ancestry.co.uk, on the basis of the first three letters of the surname. A sample was taken of the first 2 per cent of each three-letter combination for about one third of the letter combinations, the principal focus being on those born in the years 1892 to 1897, thus observed as children in the 1901 census. The age recorded on the attestation, and that which can be calculated independently (from the census), were sometimes inconsistent with the summary upon which the sampling was based. As a result a somewhat wider range of ages is observed than stipulated in the original sampling frame.

[18] For a guide to these records (for genealogists) see Spencer, 'First World War army service records.'

Given information in the service record a search was then made for each of the servicemen in the 1901 census, this time using the genealogical website Findmypast.co.uk.[19] Initially we searched by age range and name, and then, where available, other information in the service record was used for further corroboration or to discriminate between alternative possibilities. The most important pieces of corroborative information are birthplaces and the names and addresses of next of kin. One helpful feature is that few of the servicemen in the sample were married at the time of enlistment and so their next of kin was typically a parent rather than a spouse. This aids identification of the correct household in 1901. In addition to recording the key information from the 1901 census, the 'quality' of the match was assessed with grades ranging from 4 (deemed certain) to 1 (most likely). Cases for which no match was found, or where there was no basis to choose among alternatives, were discarded. Among the cases that were successfully matched, the match grades are: 4 = 54.0, 3 = 26.0, 2 = 13.1, 1 = 6.9 per cent, respectively. The resulting matched sample (grades 1-4) amounts to 2522 servicemen who grew up in England Wales out of a total of 2956 for whom the census was searched. Because each case was investigated individually, the resulting match rate of 85.3 per cent far exceeds those typical of studies that rely only on matching by computer algorithm. This should provide a reasonable degree of confidence that our sample is representative of all servicemen.

The matched sample was restricted to England and Wales for two reasons. One is that some of the information of interest is not as easily available in the Scottish or Irish censuses, specifically the number of rooms occupied by a household. More importantly, for England and Wales it is possible to capture the effects of locality at the level of the registration district rather than at the less discriminating county level. There were 635 registration districts in England and Wales with an average population of 51,222 in 1901 (as compared with the average county population of 591,383). The registration districts, based on poor law unions, span the diversity of local conditions much of which would be averaged away at the county level. Data for key variables were obtained from the Decennial Supplement to the Registrar General's 65th Annual Report.[20] This contains demographic and other statistics for the decade 1891-1900, and these data were linked to the individual's location in the 1901 census.

For the purposes of analysis some of the original matched cases were dropped, principally those for which height is missing (usually where the original document was burnt or water damaged). Also discarded were those for which the servicemen turned out not to have been born in the 1890s or enlisted before 1910 or after 1922. Also discarded were a few cases for which the household observed in the 1901 census contained more than 15 persons—usually

[19] *Findmypast* rather than *Ancestry* was used because the search engine is rather more discriminating and also because the household summary is presented in a way that lends itself more easily to data entry.
[20] See Registrar General, *Decennial Supplement to the 65th Annual Report*; most of the data used here appear in Part I, Table 1 pp. cxxx-clxiii and pp. 97-731.

lodging-houses or other institutions. The resulting sample comprises 2236 cases, forming the basis for the statistical analysis below.

Army recruitment, the heights and background of soldiers

A common concern when analyzing height data from military recruits is the minimum height restriction, several different methods having been used to correct for truncation at the lower end of the height distribution.[21] This issue is much less important for the First World War: standards declined as the War dragged on, with intensified pressure for continual military manpower recruitment. In particular the height standard which was five feet three inches at the beginning of the war was progressively relaxed,[22] beginning in November 1914 with the first Bantam regiments (for which the height range was between four feet ten inches and the normal standard).[23] The distribution of heights in our sample of servicemen is shown in Figure 1. The average height is five feet six inches, with 9.5 per cent shorter than five feet three inches tall, and 10.8 per cent taller than five feet nine. Although the mean is five feet six, for reasons that remain unclear the modal value is five feet seven.

As is well known, there was massive recruitment into the army during the Great War, with the total exceeding 5 million. It is estimated that 46 per cent of males aged 15-49 in England and Wales in 1911 were recruited into the army. Among those born in the 1890s it would have been about two thirds.[24] For this reason alone those that enlisted would have been fairly representative of this cohort of men. One dimension of representativeness is the regional composition. Table 1 compares the proportions of children aged 0 to 9 in 1901 with those in our matched sample by broad region. The sample is fairly representative although there are slightly more than expected from the regions of the south and east and somewhat fewer from the southwest and Wales.[25] The third column of Table 1 shows the average heights in inches of the servicemen in our sample. The most obvious feature is that those from the north and Wales were somewhat shorter than those from the midlands and the south.

As Bodenhorn et al. have emphasized, there are other determinants of selection into the army that may lead to biased samples of measured height, especially for volunteer armies.[26] Recruitment in the First World War was much less selective than it had been in the Boer War,

[21] See for example A'Hearn, 'A restricted maximum likelihood estimator', and Komlos, 'How to (and how not to)'.
[22] With the surge of volunteers in the first few months of the War the height standard was raised to 5' 6" in September 1914 then lowered to 5' 4" in October and back to 5'3" in November. It was further reduced to 5' 2" in May 1915. For the background to these policies, see Grieves, *The Politics of Manpower*, Ch. 1, and Simkins *Kitchener's Army*, Ch. 4.
[23] See Allinson, *The Bantams*. Bantam battalions accounted for about 50,000 recruits although many others below the height standard managed to enlist.
[24] Figure for all age groups from Winter, *The Great War,* p 28*.* The male population aged 15-24 in in 1911 was 3.2 million and the number who served (in all the forces) was approximately 2.1 million, *op. cit.,* p. 82.
[25] Similar results were found in a sample of the paper files taken by Lamm 'British soldiers", p. 81-83
[26] Bodenhorn et al., 'Problems of sample-selection bias'.

when more than a third of applicants were rejected as unfit for active service.[27] Medical examinations were notoriously superficial and the rejection rate declined as the pressure for recruits mounted, especially after the introduction of conscription, which came into effect at the beginning of March 1916.[28] [29] Army statistics indicate that among those recruited up to October 1917 almost all volunteers were classified as 'fit for general service' while only 64 per cent of conscripts were so classified.[30] By the last year of the War (when a large proportion of those fit for service had already enlisted), only 10 per cent of those examined were rejected as unfit for any kind of service.[31] [32] Only a very small proportion of these were rejected on the grounds of "poor physique", although the medical grounds for rejection could well have been correlated with height.[33] Thus the army took men with a wide range of health statuses with only limited positive selection in terms of health and height. Moreover, many of those who had not enlisted by the end of the war were in reserved occupations and were not necessarily unfit for service.

While we may conclude that conscription enhanced the representativeness of army recruits, there remain two important sources of selectivity in the sample used here. While the surviving records in W0363 seem to be a random selection of the originals they do not include those enlisting in the navy, which was generally regarded as a more elite service. More importantly, officers joining the army on commissions are also omitted. These were about five per cent of the total army strength and they were drawn almost entirely from among men with upper and middle class backgrounds.[34] They are likely to have been fitter and taller than those from the lower classes. One estimate puts the mean height of officers at five feet nine inches.[35] At the other end of the scale, WO363 excludes many of the much smaller number of records that were transferred to the Ministry of Pensions. These evidently include a higher proportion

---

[27] Over the decade 1893 to 1902, 34.6% of those who underwent the army medical examination were rejected and a further 3% were discharged on medical grounds within two years, see Inter-departmental Committee on Physical Deterioration, '*Report*', Appendix 1, pp. 95-97. As an unknown proportion of volunteers were rejected by recruiting officers without being subjected to medical inspection the total rejection rate would have been much higher, possibly more than half.

[28] Winter, *The Great War*, pp. 50-3, describes the controversy arising from the inadequacy of medical examinations, noting that the doctors were paid only for those that they passed as fit.

[29] The Military Service Act of 1916 was passed in January and came into force on March 2nd 1916. It included all men aged 18 to 41 unless they were married or widowed with children. A further act of May 1916 that extended conscription to married men is less relevant to our sample, only 8.3% of whom were married upon enlistment. Those attesting under the Derby scheme are counted as volunteers, as seems appropriate.

[30] Army Council, *General Annual Reports*, p. 9. During the period of conscription the proportion of volunteers was a small minority—only 12.5% (*ibid*, p. 60). Just over 20% of our sample enlisted during the era of conscription and these were shorter than volunteers, on average by 0.3 of an inch ('t' = 2.2).[30]

[31] Winter, *The Great War*, p. 57.

[32] Following the medical examination they were assigned a letter grade, where 'A" was 'fit for general service', B was 'fit for service abroad in a support capacity' and C was 'fit for home service only'.

[33] The Ministry of National Service, *Report*, provides a compilation of statistics from the examinations conducted by the National Service Medical Boards that were established in 1917.

[34] Simpson, 'The officers', p. 91.

[35] Pembury, 'Tall men versus short men,' p. 112 (comments by Sir Launcelot Gubbins).

of records of those who were discharged on medical grounds or as ‘unlikely to become an efficient soldier”.[36]

The men in our sample enlisted relatively early in the war. As shown in Table 2, the average date of attestation is half way through 1915, with 20 per cent enlisting after the introduction of conscription in March 1916. Age at the time of enlistment is measured in two ways, first from the attestation form and second by combining the date of attestation and the age recorded in the 1901 census. Although the sample means are similar, the ages as measured by these alternative methods often differ, with a correlation coefficient of only 0.83. In part this is because age is recorded as whole years in the census and thus the calculated age is not precise to the month. But in 12 per cent of cases the age difference is more than two years. The average age of these individuals when observed in the 1901 census is 5.5 years and their average birth order is 3.

The middle panel of Table 2 shows the mean family characteristics of the matched servicemen as children in 1901. The average household consisted of 6.5 people with an average of 4.2 children in the family. On one hand we should expect to oversample relatively large families; but on the other hand many of the families are incomplete when observed in the census. Of the 98 per cent of households with a mother present her average age is 35.6. Of these, 19 per cent were aged under 30 and 24 per cent were over 40. Nearly 6 per cent of households were headed by females and in 7.6 per cent of households the mother reported a gainful occupation. Not surprisingly, among female heads nearly half reported an occupation. The average number of earners in the household is 1.8 with over half having just one earner. Finally the occupation of the head of household was coded according to the Registrar General’s 1921 social classification as suggested by Armstrong (rather than that of 1911).[37] Only 13.2 per cent were in social classes 1 and 2 (professional and managerial) with a further 46.3 per cent in class 3 (skilled).

The last part of Table 2 shows the average characteristics of the registration district in which the household was located in 1901. Households are observed in 473 out of the 635 registration districts. Not surprisingly these were typically the larger districts with an average population of nearly 150,000 and with a density of nearly 21 persons per acre.[38] The average individual in our sample was living in a district where 5.6 per cent of households were overcrowded on the conventional measure of more than two persons per room. The Registrar General produced a rough classification of registration districts as heavily industrial or agricultural.[39] These districts account for 27 per cent and 14 per cent, respectively, of those in our sample while the remainder came from mixed districts, provincial towns, and most

---

[36] Lamm, ‘British soldiers’, p. 62.
[37] Armstrong, “The use of information,” p. 205.
[38] At the 1901 census the average person lived in a registration district with a population of 139,539 and a density of 20.02 persons per acre.
[39] This classification was taken from the Registrar General, *Decennial Supplement to the 65th Annual Report,* p. viii.

importantly, London. The average rate of infant mortality in these districts from 1891 to 1900 was 152 per thousand—close to the average for England and Wales. The average district mortality rate in the age range 0 to 9 was 30 per thousand. In order to explore the effects of education we also constructed a proxy for the district literacy rates of the parents' generation by taking the percentage of brides and grooms signing the marriage register with a mark in the years 1881 to 1884.[40] These show that, in the districts represented in our sample, more than 15 per cent of women and 12 per cent of men were illiterate at the time of marriage.

Height and the household

Here we explore how the heights of army recruits are related to the characteristics of the household in which they grew up, an investigation rarely possible using historical data. The first column of Table 3 reports the results with only demographic variables included. Age at enlistment is that calculated from the date of attestation and age as reported in the census. As expected those aged less than 18 were significantly shorter, by more than half an inch, and those aged 18 and 19 by about quarter of an inch, relative to the omitted group (age 22 and above). These effects are modest but they are consistent with the findings of others. In what follows we compare the results using instead the age recorded on enlistment.

Birth order is naturally correlated with family size, as high birth orders are observed only in large families. In order to avoid conflating the separate effects of birth order and sibship size we use an adjusted measure of birth order: the difference between the individual's birth order and the sibship mean birth order. The result in column (1) suggests that, in contrast to some studies, there is no strong birth order effect on height as the coefficient is small and insignificant. More interesting is the effect of sibship size. The coefficient in column (1) indicates that height is inversely related to the number of children in the family. This reflects the trade-off between the quantity and the 'quality' of children in the health dimension. Across the range of family sizes from one to ten this would amount to a difference of more than an inch.[41]

It is important to recognize, however, that the families observed here are often incomplete and hence some of the children would have gained further siblings after 1901. We therefore include the age of the mother in 1901 to account for the likelihood of further siblings. The result is consistent with the notion that the older the mother, the smaller the expected addition to family size, and hence the positive effect on height. Mother's age is set to zero where there is no mother present: consequently a dummy variable is also included to account for families where no mother was present and no further siblings would be expected.[42] As an

[40] 1884 is the latest date for which this measure of literacy is reported by registration district. The mean age of first marriage for women in the 1880s was a little over 27 (Woods, *The demography of Victorian England and Wales*, p. 89).
[41] However, this effect is considerably smaller than that estimated for children in poor families in the 1930s, see Hatton and Martin, 'The effects on stature' p. 171.
[42] The effect of the dummy for 'no mother present' is equivalent to having a mother aged 1.399/0.042 = 33.3.

alternative to adjusting for incomplete families by using separate variables we create an adjusted sibship measure, in which expected future births are added to the observed sibship size. This is based on a regression of sibship size on mother's age.[43] The coefficient on predicted sibship size in column (2) gives a slightly larger coefficient with little change to the coefficients on other variables. Of course, mother's age and no mother present could have direct effects on height, and when added to the column (2) regression, these were jointly significant ('F' = 3.19).[44]

A further hypothesis is that health and height depends on the sex composition of the sibship. If boys were given preference over girls then the share of girls in the sibship should have a positive effect on height. However, when added to the regression in column (1) the share of girls took a small and insignificant coefficient ('t' = 1.14). Neither is there evidence of a significantly more negative effect for large families; a dummy variable for sibships greater than four yields an insignificant coefficient ('t' = 0.84).

Other economic characteristics are added in column (3). The dummy for female headed households gives a negative coefficient, and the effect of a working mother is positive, though neither coefficient is significant. The ratio of earners (those with occupations) to total persons in the household yields a significant negative coefficient, implying that, in a six person household, going from two to three earners reduces height by quarter of an inch. Although a greater share of earners should mean more income per capita, the negative effect could be due to the marginalization of the needs of children relative to earners. Most of the additional earners are immediate family members: hence the negative effect is consistent with priority given to breadwinners in household resource allocation. Alternatively, greater participation could simply be a response to poverty, which in turn is associated with height. The negative estimate does not seem to result from crowding within the household, an effect captured by a dummy variable for more than one person per room and which itself yields a significant negative coefficient. The effect of growing up in a crowded household is estimated to reduce adult height by nearly a third of an inch. This is consistent with the arguments of contemporaries and subsequent observers, who have stressed the negative effects of crowded and squalid conditions on children's health through the spread of infection.

[43] The regression coefficient for mothers aged 20 to 40 is 0.191 ('t'= 20.4). Thus for a mother aged 20 we add (40 – 20)* 0.191 = 3.82 children and for a mother aged 30 we add (40 – 30)*0.191 = 1.91 children. For families where the mother is over 40 or there is no mother present, no further children are added. This gives an average predicted sibship size of 5.19 as compared with the unadjusted average of 4.16. It is possible that in families with older mothers some siblings had left home, but the decline in family size with age for mothers aged over 40 is very mild.

[44] Another issue is that, even though height is observed later than sibship size, endogeneity bias could arise from unobserved heterogeneity, giving rise to spurious correlation between height and sibship size. If mother's age and 'no mother present' are used as instruments for predicted family size, the coefficient is -0.299 ('t' = 3.35). This is consistent with the finding of Hatton and Martin, 'The effects on stature' p. 172, in that instrumental variable estimation produces a negative coefficient which is larger in absolute size than ordinary least squares. One possible reason for a bias towards zero in the ordinary least squares estimate is that families with inherently poor heath have fewer surviving children.

Although such inferences are often drawn from correlations across localities, here the effect is observed at the household level.

The social status of the family is represented by the occupational class of the household head. Here we include dummy variables for professional and managerial (class 1 or 2) and skilled occupations (class 3) in the Registrar General's 1921 classification.[45] Servicemen who grew up in middle class families were taller than those from unskilled families by nearly half an inch. But the effect for skilled household heads is close to zero. Of course, social class is a poor proxy for income. Nevertheless the result is a little surprising given the link between occupational class, health and mortality identified by the Registrar General in 1911 and by many others since.[46] It suggests that some of the difference in height between classes and occupations works through family size and crowding within the household. As an alternative, in column (4), we use the HISCAM occupational status score and find a weak positive effect for those occupations that could be coded.[47]

Two sources of measurement error could affect the results, the influence of which can be compared using a baseline regression reported in column (1) of Table 4, in which the least significant variables have been dropped. The first source of error is the reporting of age. Although there is little difference in the mean age at enlistment as calculated from age in the 1901 census and that recorded on the attestation form, it is possible that taller men systematically overstated their age. However there is only a weak correlation (0.04) between height and difference between the age recorded on the attestation form and that calculated from age in the census and date of attestation. The regression in column (2) of Table 4 uses the attestation age rather than the census-based age. This gives coefficients for the younger age groups that are more negative and more significant, suggesting some systematic difference.[48] However, the other coefficients are little affected by this change and so in what follows we continue to use age calculated from the census.

A second potential source of error is that the army recruit has been matched to the wrong person in the census. This could account for the weaker age effects obtained when using census-based age rather than that recorded on the attestation. Accordingly column (3) omits the cases with lower match quality (1 or 2). The coefficients on the age variables change very little as compared with column (1), suggesting that the differences in the age effects between columns (1) and (2) do not result from false matches. The coefficients in column (3) for other the household variables are little changed.

[45] Classes 1 and 2 are combined because there are only 16 cases where the household head is in Class 1.
[46] Registrar General of England and Wales, Seventy-fourth annual report, pp. xl-xlv.
[47] HISCAM is an index of social hierarchy based on social interactions between individuals by occupation; for further details see Lambert et al., 'The construction of HISCAM'. The occupations were first coded using the HISCO coding scheme at: http://historyofwork.iisg.nl/index.php and then converted into the HISCAM index using the universal scale at: http://www.camsis.stir.ac.uk/hiscam/.
[48] When added to the regression in column (2) the dummy variables representing ages 20 and 21 remain insignificant ('t' = 1.19 and 1.47 respectively).

Finally, as noted above, the observed household effects could partially reflect differences across regions. Column (4) includes a full set of county dummy variables (coefficients not reported). The main differences are that ‘no mother present’ and ‘crowding’ lose significance while the effect of social class increases in size and significance. The R^2 also increases substantially suggesting that spatial differences matter, and we investigate this next.

Height and the Locality

We explore the effects of conditions in the locality as defined by the registration district. One question is the extent to which household effects are attenuated when locality characteristics are included. A related question is which locality effects are important and, if so, what they represent. Table 5 presents the results of adding locality variables to the baseline specification in column (1) of Table 4. Column (1) of Table 5 includes district population density, which although negative, is insignificant. It is possible that population density matters only beyond a certain threshold, but if this variable is replaced with a dummy for population density greater than 20 persons per acre, or 50 persons per acre, the coefficients (not reported) are similarly insignificant (‘t’ = 0.55 and ‘t’ = 0.70 respectively). Population density was evidently less important at the turn of the century that it was 50 years earlier. By contrast overcrowding, as conventionally measured, is rather more important, giving a negative and significant coefficient (column 2), which weakens the coefficient on crowding at the household level but has little effect on the other household coefficients.

Column (3) of Table 5 adds two dummy variables representing the Registrar General’s broad classification of registration districts as ‘industrial’ or ‘agricultural’, the remainder being provincial towns and, above all, London. Agricultural location has little effect on height, probably because markets were well integrated by this time. By contrast the industrial locations reduced height by nearly 0.9 of an inch, giving credence to the view that, even accounting for household conditions, industrial environments negatively affected growth in childhood. The coefficient on the share of earners in the household, which was higher in industrial districts, is somewhat reduced, but there is little effect on the other coefficients.[49]

The last column of Table 5 adds an estimate of the district-level illiteracy rate of women who would have been of parental age in 1901. This is the percentage of women signing the marriage register by mark in the early 1880s. It has a significant negative coefficient, which implies that reducing the illiteracy rate by 10 percentage points would add quarter of an inch to height. The effect of mother’s education has often been linked to the health of children at the individual level. Unfortunately we are able to observe this only at the district level, but it is possible that greater education and literacy in a locality helped to spread better methods of child nurturing. An alternative interpretation is that the variable could be a proxy for

[49] It is possible that the dummy variables for type of district capture sources of regional differences in height other than those shown in Table 1. However the estimated coefficients on the agricultural and industrial dummies are little affected by the addition of ten region dummy variables, even though the latter are jointly significant (F = 4.14).

average income in the locality but, if so, the effect would be better represented by male literacy. When the male illiteracy rate is added to the regression in column (4) it produced a positive coefficient ('t' = 2.16) while that on female illiteracy remains large and significantly negative.

A more direct proxy for the disease environment is infant mortality. As noted above, variations in infant mortality are driven largely by gastro-intestinal and respiratory illnesses—infections that also inhibit the growth of children. As the first column of Table 6 shows, the average rate of infant mortality in the registration district in 1891-1900 has a strong negative effect on height. This suggests that the local disease environment had an important influence on health and height, the negative coefficient implying that the scarring effect of infections dominated the selection effect. It is consistent with the findings of other studies, both in cross-sections and over time.[50] The difference between the first and third quartiles of infant mortality (4 percentage points) accounts for more than half an inch in height while the difference between the highest and lowest deciles accounts for nearly an inch.

A potential source of measurement error is for cases in which the family moved location sometime after the individual's birth but before the 1901 census. In that event the locality recorded at the census would only partially reflect the individual's early life environment. Because birthplaces are not consistently reported by registration district in the census, movers are identified as those who, in 1901, were living in a county other than that in which they were born.[51] The results reported in column (2) excludes movers: with the exception of social class, the coefficients differ only marginally from those in column (1). Most importantly the coefficient on infant mortality is little changed. On this basis we conclude that the results are not substantially affected by measurement error due to migration.

The results reported in column (3) of Table 6 show that when the female illiteracy rate is added to the regression, the effect of infant mortality declines, suggesting that infant mortality reflects, in part, the knowledge and skills of mothers in the locality, as some contemporary observers suggested.[52] Column (4) adds district overcrowding and the dummy variable for industrial districts, in the presence of which, the coefficient on infant mortality diminishes further in size and significance. Consistent with other studies, the local disease environment, as reflected in infant mortality appears to be linked to education, overcrowding and industry.[53] Table 7 shows the relationship between infant mortality and these three variables across the 635 registration districts. Each has a strong positive effect and together they account for more than 40 per cent of the variation in infant mortality. Overall the results

[50] In a panel of town-level data for children aged 2-6 between 1920 and 1950 the equivalent coefficient converted to inches would be approximately – 0.1 (Hatton, 'Infant mortality', Table 3 p. 966).
[51] A regression of a dummy variable for movers on the individual's age in 1901 suggests that the probability of having moved away from the county of birth increases by 0.011 per year of age (t = 3.08).
[52] Newman, *Infant mortality*, p. 262-8; see also Fildes, 'Infant feeding practices'.
[53] Woods et al. 'The causes of rapid infant mortality decline', and Newell and Gazeley, 'The declines in infant mortality'.

support the view that locality effects were important, that they work mainly through the disease environment, and that they are largely independent of the structure of the individual household.

Conclusion

As this paper has shown, census-linked data from the army service records offer insights into the socioeconomic circumstances affecting the height and health of men born in the 1890s. The demographic structure of the household was found to be important, especially the negative effect on height of number of children in the family. The degree of crowding in the household, the share of earners and social class also played a role. These channels of influence cannot be easily assessed using grouped data for regions and localities; moreover their effects are robust to the inclusion of a range of variables representing the conditions in the locality. Yet, in contrast with evidence for more recent times, locality effects are distinct and important. The results suggest that the channel through which these local effects operated was principally via exposure to infection and disease, three factors that influenced the disease environment being found to be overcrowding (capturing the effects of slum dwellings) the industrial character of the district, and the degree of female illiteracy. This last effect is consistent with the findings for developing countries and deserves further attention.

The results reported here have implications for understanding the dramatic improvement in health after 1890. In the following half century the height of males increased by about two inches. This was partly due to greater availability of calories as incomes increased. But it was also a period of rapid fertility decline, which reduced the average family size from around five children to two. This could have increased height by about a third of an inch. It also witnessed a decline in the rate of infant mortality from around 15 per cent to just 6 per cent, which would have added around one and a third inches. Improvements in the urban environment with the further advance of sanitary reform and housing renewal, and the gradual reduction of industrial pollution also contributed. Illiteracy virtually disappeared while average education increased by 2-3 years. More education combined with modest medical advances, brought better understanding of nutrition and hygiene. Together these developments help to explain the apparent puzzle of rapid improvement in average health status during a period of war and depression that predates the advent of universal health services.

References

A'Hearn, B. (2003), "Anthropometric evidence on living standards in northern Italy, 1730-1860," *Journal of Economic History*, 63, pp. 351-381.

A'Hearn, B. (2004), "A restricted maximum likelihood estimator for truncated height samples," *Economics and Human Biology* 2, pp. 5–19.

Allinson, S. (2009), *The bantams: The untold story of World War I*, Barnsley, South Yorkshire: Pen and Sword Military.

Armstrong, W. A. (1972), "The use of information about occupation," in E. A. Wrigley (ed.), *Nineteenth-century society: Essays in the use of quantitative methods for the study of social data,* Cambridge: Cambridge University Press, pp. 191-310.

Baten, J. (2009), "Protein supply and nutritional status in nineteenth century Bavaria, Prussia and France," *Economics and Human Biology,* 7, pp. 165-180.

Baten, J. and Murray, J. E. (2000), "Heights of men and women in 19th century Bavaria: Economic, nutritional and disease influences," *Explorations in Economic History,* 37, pp. 351-369.

Bodenhorn, H., Guinnane, T. W. and Mroz, T. A. (2013), "Problems of sample-selection bias in the historical heights literature: A theoretical and econometric analysis," Yale Economics Working Paper No. 114.

Bozzoli, C., Deaton, A. S. and Quintana-Domeque, C. (2009), "Adult height and childhood disease" *Demography,* 76, pp. 647-669.

Breschi, M., Fornasin, A., Manfredini, M., Mazzoni, S. and Pozzi, L. (2011), "Socioeconomic conditions, health and mortality from birth to adulthood, Alghero 1866–1925," *Explorations in Economic History,* 48, pp. 366–375

Burstrom, B., Diderichsen, F and Smedman, L. (1999), "Child mortality in Stockholm during 1885-1910: The impact of household size and number of children in the family on risk of death from measles," *American Journal of Epidemiology*, 149, pp. 1134-1141.

Cage, R. A. and Foster, J. (2002), "Overcrowding and infant mortality: A tale of two cities," *Scottish Journal of Political Economy*, 49, pp. 129-149.

Cavelaars, A. E. J. M., Kunst, A. E., Geurts, J. J. M., Crialesi, R., Grötvedt, L., Helmert, U., Lahelma, E., Lundberg, O., Mielk, A., Rasmussen, N. K., Regidor, E., Spuhler, T. and Mackenbach, J. P. (2000), "Persistent variations in average height between countries and between socio-economic groups: an overview of 10 European countries," *Annals of Human Biology*, 27, pp. 407-421.

Fildes, V. (1998), “Infant feeding practices and infant mortality in England, 1900-1919,” *Continuity and Change*, 13, pp. 251-280.

Grieves, K. (1988), *The politics of manpower, 1914-1918, Manchester*: Manchester University Press.

Haines, M. R., Craig, L.A. and Weiss, T. (2003), “The short and the dead: nutrition, mortality and the “antebellum puzzle” in the United States,” *Journal of Economic History*, 63, pp. 382-413.

Hatton, T. J. (2011), “Infant mortality and the health of survivors: Britain, 1910-1940,” *Economic History Review*, 64, pp. 951-972.

Hatton, T. J. and Martin, R. M. (2010), “The effects on stature of poverty, family size and birth order: British children in the 1930s,” *Oxford Economic Papers,* 62, pp. 157-184.

Horrell, S. and Oxley, D. (1999), "Crust or crumb? Intra-household resource allocation and male breadwinning in late Victorian Britain,” *Economic History Review*, 52, pp. 494-522.

Horrell, S. and Oxley, D. (2012), “Bringing home the bacon? Regional nutrition, stature and gender in the industrial revolution,” *Economic History Review,* 65, pp. 1354-1379.

Humphries, J. (2007), “‘Because they are too menny...’ children, mothers, and fertility decline: The evidence from working-class autobiographies of the eighteenth and nineteenth centuries,” in A. Janssens (ed.), *Gendering the fertility decline in the western world,* Bern: Peter Lang, pp. 113-150.

Humphries, J. and Leunig, T. (2009), “Cities, market integration, and going to sea: stunting and the standard of living in early nineteenth-century England and Wales,” *Economic History Review*, 62, pp. 458–478.

Komlos, J. (2004), “How to (and how not to) analyze deficient height samples—an introduction,” *Historical Methods,* 37, pp. 160–173.

Komlos, J. and Lauderdale, B. E. (2007), “Spatial correlates of US heights and body mass indexes 2002,” *Journal of Biosocial Scienc*e, 39, pp. 59–78.

Lambert, P. S., Zijdeman, R. L., Van Leeuwen, M. D. H., Maas, I. and Prandy, K. (2013), “The Construction of HISCAM: A stratification scale based on social interactions for historical comparative research,” *Historical Methods*, 46, pp. 77-89.

Lamm, D. (1988), “British soldiers of the First World War: Creation of a representative sample,” *Historical Social Research/Historische Sozialforschung*, 13, pp.55-98.

Lantzsch, J. and Schuster, K. (2009), “Socioeconomic status and physical stature in 19th-century Bavaria,” *Economics and Human Biology*, 7, pp. 46–54.

Martikainen, P., Kaupinnen, T. M. and Valkonen, T. (2003), “Effects of the characteristics of neighbourhoods and the characteristics of people on cause specific mortality: A register-based follow up study of 252 000 men,” *Journal of Epidemiology and Community Health,* 57, pp. 210-217.

Newell, A. and Gazeley, I. (2012), “The declines in infant mortality and Fertility: Evidence from British cities in demographic transition,” IZA Discussion Paper No. 6855

Newman, G. (1906), *Infant mortality: A social problem,* London: Methuen.

Pembury, M. S. (1915), “Tall men versus short men for the army,” *Journal of the Royal Sanitary Institute*, 36, pp. 105-113.

Pickett, K. E. and Pearl, M. (2001), “Multilevel analyses of neighbourhood socio-economic context and health outcomes: A critical review,” *Journal of Epidemiology and Community Health*, 55, pp. 111–122.

Rowntree, B. S. (1901), *Poverty: A study of town life*, London: Macmillan.

Schneider, R. (1996), “Historical note on height and parental consumption decisions,” *Economics Letters,* 50, pp. 279-283.

Simkins, P. (1988), *Kitchener’s army: The raising of the new armies, 1914-1916*, London: Pen and Sword.

Simpson, K. (1985), “The officers,” in I. F. W. Beckett and K. Simpson (eds.), *A nation in arms: A social study of the British army in the First World War,* Barnsley: Pen and Sword.

Spencer, S. (2008), *First World War army service records: A guide for family historians,* Richmond, Surrey: National Archives.

Stafford, M. and Marmot, M. (2003), “Neighbourhood deprivation and health: Does it affect us all equally?” *International Journal of Epidemiology,* 32, pp.357–366.

Steckel, R. H. (1995), “Stature and the standard of living,” *Journal of Economic Literature,* 33, pp. 1903-1940.

Steckel, R. H. (2009), “Heights and human welfare: Recent developments and new directions,” *Explorations in Economic History,* 46, pp. 1-23.

Szreter, S. and Mooney, G. (1998), "Urbanisation, mortality and the standard of living debate; new estimates of the expectation of life at birth in nineteenth-century British cities," *Economic History Review,* 50, pp. 84–112.

Vynke, V., De Clercq, B., Stevens, V., Costongs, C.,Barbareschi, G., Jónsson, S. H., Corvo, S. D., Kebza, V., Currie, C. and Maes, L. (2013), "Does neighbourhood social capital aid in levelling the social gradient in the health and well-being of children and adolescents? A literature review," *BMC Public Health*, 13, Art 65.

Weir, D. R. (1993), "Parental consumption decisions and child health during the early French fertility decline, 1790-1914," *Journal of Economic History,* 53, pp. 259-274.

Williams, N. and Galley, C. (1995), "Urban-rural differentials in infant mortality in Victorian England," *Population Studies*, 49, pp. 401-420.

Winter, J. M. (2004), *The Great War and the British people* (2nd edn.), London: Palgrave Macmillan.

Woods, R. I. (2000), *The demography of Victorian England and Wales*, Cambridge: Cambridge University Press.

Woods, R. I., Watterson, P. A. and Woodward, J. H. (1989), "The causes of rapid infant mortality decline in England and Wales, 1861- 1921. Part II," *Population Studies*, Vol. 43, pp. 113-132.

Official Documents

Army Council (1921), *General annual reports on the British army (Including the Territorial Force from the date of embodiment) for the period from 1st October 1913 to 30th September 1919,* (Cmd. 1193), HMSO.

Inter-departmental Committee on Physical Deterioration (1904), *Report and Appendix* (CD. 2175), HMSO.

Ministry of National Service 1917-1919 (1920), *Report, Vol. I, Upon the physical examination of men of military age by national service medical boards from November 1st 1917-October 31st, 1918* (Cmd. 504), HMSO.

Registrar General of England and Wales (1907), *Supplement to the sixty-fifth annual report of the Registrar General of Births Deaths and Marriages in England and Wales, 1891-1900,* (Cd. 2618), HMSO.

Registrar General of England and Wales (1913), *Seventy-fourth annual report of the Registrar General of Births Deaths and Marriages in England and Wales, 1911,* (Cd. 6578), HMSO.

Table 1: Regional composition of population and servicemen in 1901 and average height

Registration Division		1901 Census	Servicemen Sample	Average Height
I	London	13.5	15.1	66.16
II	South Eastern	9.5	11.3	66.79
III	South Midland	6.6	6.8	66.94
IV	Eastern	5.9	7.6	66.10
V	South Western	6.0	4.5	66.77
VI	West Midland	11.5	10.6	66.08
VII	North Midland	6.4	6.9	66.07
VIII	North Western	16.0	14.5	65.55
IX	Yorkshire	11.0	13.5	65.31
X	Northern	7.0	6.2	65.83
X1	Wales	6.4	3.1	65.79

Table 2: Descriptive statistics of servicemen-linked sample

Individual Characteristics	Mean	S.D.
Height (inches)	66.06	2.57
Attestation date (year)	1915.5	1.36
Age recorded at attestation	20.53	1.96
Age calculated from age in 1901	20.26	2.29
Birth order in 1901	3.04	1.88
Household characteristics		
Persons in household	6.54	2.14
Sibship size	4.16	2.08
Mother’s age (if mother present)	35.6	6.70
Female household head (%)	6.03	23.8
Mother an earner (%)	7.64	26.6
Earners per household	1.81	1.15
Head social class 1 & 2 (%)	13.2	33.8
Head social class 3 (%)	46.3	49.9
More than 1 person per room (%)	46.4	49.9
Locality characteristics		
Population (000s) 1901	148.6	126.9
Population density (persons per acre) 1901	20.8	36.7
More than 2 per room (%) 1901	5.6	6.3
Infant mortality rate (%) 1891-1900	15.2	2.9
Child mortality rate, 0-9 (%) 1891-1900	3.0	0.9
‘Industrial’ district (%)	27.0	44.4
‘Agricultural’ district	14.3	35.0
Female illiteracy (%) 1881-4	15.3	9.2
Male Illiteracy (%) 1881-4	12.6	6.6

Table 3: Household Determinants of Height (in inches)

	(1)	(2)	(3)	(4)
Age < 18	-0.575 (2.86)	-0.729 (2.41)	-0.638 (3.10)	-0.657 (3.18)
Age 18	-0.250 (1.47)	-0.385 (2.28)	-0.338 (1.97)	-0.350 (2.01)
Age 19	-0.297 (1.64)	-0.389 (2.28)	-0.374 (2.08)	-0.382 (2.11)
Age 20	-0.073 (0.42)	-0.070 (1.39)	-0.150 (0.87)	-0.140 (0.81)
Age 21	-0.018 (0.09)	-0.010 (0.05)	-0.039 (0.20)	-0.029 (0.14)
Birth order index	-0.037 (0.56)	0.070 (1.39)	0.018 (0.26)	0.017 (0.26)
Sibship size	-0.110 (3.54)		-0.134 (4.17)	-0.140 (4.43)
Mother's age in 1901	0.042 (4.11)		0.045 (4.57)	0.048 (4.72)
No mother present	1.399 (2.72)		1.608 (3.13)	1.742 (3.33)
Predicted sibship size		-0.139 (4.58)		
Female head of household	-0.457 (1.89)	-0.447 (1.83)	-0.377 (1.29)	-0.328 (1.09)
Mother an earner			-0.198 (0.66)	-0.158 (0.52)
Earners/persons in household			-1.519 (3.03)	-1.659 (3.33)
More than 1 person per room			-0.278 (2.39)	-0.322 (2.91)
Head social class 1 & 2			0.447 (2.71)	
Head social class 3			-0.060 (0.50)	
HISCAMoccupational status				0.013 (1.83)
Occupation not classified				0.770 (1.77)
F-statistic	5.38	6.08	6.18	5.69
R-squared	0.022	0.021	0.038	0.036
No of observations	2236	2236	2236	2235

Note: *t*-statistics from robust standard errors clustered at the registration district level. Reference categories: age 22 and over; social classes 4 and 5.

Table 4: Household Effects on Height--Alternative Specifications

	(1)	(2)	(3)	(4)
	Baseline model	Age from attestation form	High match quality (>2)	County dummies included
Age < 18	-0.575	-1.051	-0.575	-0.697
	(3.57)	(4.37)	(3.57)	(4.39)
Age 18	-0.259	-0.667	-0.256	-0.272
	(1.80)	(4.16)	(1.57)	(1.76)
Age 19	-0.308	-0.403	-0.308	-0.320
	(2.03)	(3.32)	(1.91)	(2.17)
Sibship size	-0.126	-0.122	-0.137	-0.112
	(4.38)	(4.22)	(4.20)	(3.90)
Mother's age in 1901	0.047	0.044	0.047	0.036
	(5.23)	(4.75)	(4.64)	(3.68)
No mother present	1.664	1.590	1.805	1.182
	(3.47)	(3.27)	(3.36)	(2.23)
Earners/persons in household	-1.656	-1.682	-1.690	-1.063
	(3.91)	(3.97)	(3.46)	(2.47)
More than 1 person per room	-0.287	-0.289	-0.325	-0.174
	(2.45)	(2.48)	(2.38)	(1.51)
Head social class 1 & 2	0.466	0.461	0.368	0.513
	(2.93)	(2.94)	(2.11)	(3.12)
F-statistic	12.63	12.63	7.85	3.55
R-squared	0.036	0.043	0.036	0.089
No of observations	2236	2236	1831	2236

Note: *t*-statistics from robust standard errors clustered at the registration district level, except col. (4).
Reference categories: age 20 over; social classes 3, 4 and 5.

Table 5: Locality Determinants of Height (in inches)

	(1)	(2)	(3)	(4)
Age < 18	-0.571 (3.54)	-0.614 (3.79)	-0.677 (4.25)	-0.694 (4.43)
Age 18	-0.262 (1.81)	-0.273 (1.90)	-0.263 (1.88)	-0.283 (2.03)
Age 19	-0.311 (2.05)	-0.310 (2.02)	-0.318 (2.14)	-0.339 (2.29)
Sibship size	-0.126 (4.38)	-0.123 (4.20)	-0.115 (3.88)	-0.111 (3.80)
Mother's age in 1901	0.046 (5.19)	0.044 (4.86)	0.038 (4.40)	0.037 (4.24)
No mother present	1.648 (3.44)	1.561 (3.24)	1.332 (2.83)	1.267 (2.72)
Earners/persons in household	-1.643 (3.89)	-1.619 (3.84)	-1.083 (2.55)	-1.035 (2.48)
More than 1 person per room	-0.271 (2.26)	-0.191 (1.60)	-0.169 (1.43)	-0.148 (1.27)
Head social class 1 & 2	0.471 (2.96)	0.491 (3.13)	0.555 (3.61)	0.533 (3.48)
District population density, 1901 (100s per acre)	-0.131 (0.90)	0.195 (1.01)	0.113 (0.65)	-0.157 (0.81)
District percentage of households >2 persons per room, 1901		-0.036 (2.82)	-0.037 (3.13)	-0.020 (1.46)
District "Industrial"			-0.876 (5.71)	-0.632 (3.88)
District "Agricultural"			-0.009 (0.06)	-0.053 (0.33)
District female illiteracy, percentage of marriages, 1881-4				-0.028 (3.52)
F-statistic	8.54	8.54	11.29	12.15
R-squared	0.036	0.036	0.063	0.069
No of observations	2236	2236	2236	2236

Note: *t*-statistics from robust standard errors clustered at the district level. Reference categories: age 20 over; social classes 3, 4 and 5; mixed industrial districts.

Table 6: Height (in inches) and Infant Mortality

	(1)	(2)	(3)	(4)
Age < 18	-0.621 (4.04)	-0.599 (3.63)	-0.662 (4.28)	-0.686 (4.42)
Age 18	-0.289 (2.03)	-0.289 (1.50)	-0.299 (2.12)	-0.288 (2.06)
Age 19	-0.325 (2.23)	-0.297 (1.83)	-0.338 (2.30)	-0.336 (2.29)
Sibship size	-0.110 (3.88)	-0.105 (3.57)	-0.106 (3.79)	-0.107 (3.74)
Mother's age in 1901	0.037 (4.30)	0.033 (3.83)	0.036 (4.17)	0.035 (4.08)
No mother present	1.238 (2.72)	1.274 (2.65)	1.213 (2.67)	1.186 (2.59)
Earners/persons in household	-1.141 (2.79)	-0.957 (2.27)	-1.104 (2.71)	-0.974 (2.36)
More than 1 person per room	-0.195 (1.65)	-0.215 (1.74)	-0.177 (1.53)	-0.153 (1.31)
Head social class 1 & 2	0.510 (3.29)	0.378 (2.07)	0.498 (3.21)	0.534 (3.48)
District infant mortality rate (percentage)	-0.146 (7.40)	-0.147 (6.99)	-0.104 (4.30)	-0.065 (2.25)
District female illiteracy, percentage of marriages, 1881-4			-0.025 (3.33)	-0.019 (2.41)
District percentage of households >2 persons per room, 1901				-0.016 (1.52)
District "Industrial"				-0.466 (2.57)
F-statistic	14.34	11.06	13.95	13.29
R-squared	0.062	0.057	0.067	0.067
No of observations	2236	1971	2236	2236

Note: *t*-statistics from robust standard errors clustered at the district level. Reference categories: age 20 over; social classes 3, 4 and 5; agricultural and mixed industrial districts.

Table 7: Determinants of Infant Mortality (District Level)

$$\underset{(57.55)}{\text{Infant mortality} = 9.877} + \underset{(10.07)}{0.174}\ \text{Overcrowding} + \underset{(10.30)}{3.358}\ \text{Industrial} + \underset{(10.61)}{0.123}\ \text{Female illiteracy}$$

R^2 = 0.428, N = 635, 't' statistics in parentheses.

Figure 1: Distribution of heights in the matched sample of army recruits